NASA ADVANCED SUPERCOMPUTING (NAS) DIVISION

APPLICATION PERFORMANCE OPTIMIZATION

The performance and productivity of high-end computing applications is key to facilitating advances in science and engineering research for NASA missions.

Benefit

With key modeling and simulation problems continually growing in size and complexity, improving the performance and productivity of high-end computing (HEC) applications is essential to advancing NASA's science and engineering achievements. The NAS Division's Application Performance and Productivity (APP) team helps users make the most effective use of their codes to run efficiently on current parallel processing systems.

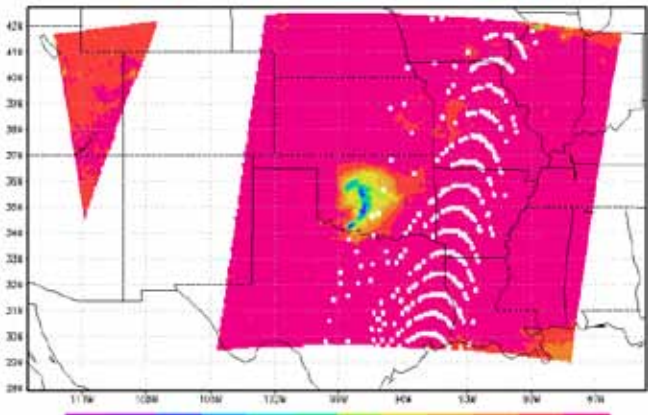
Direct benefits in cost- and time-savings are associated with scaling codes. For example, code performance improvements in NASA's weather and climate modeling projects help produce more accurate and timely rainfall predictions—potentially resulting in savings to both lives and property. Scaling codes can have other benefits as well. For instance, by speeding up simulations for next-generation space transportation vehicles, NAS application experts give designers the opportunity to increase the fidelity of individual runs or make additional runs without an increase in computer resources used. The result can be a higher confidence in design of the model before wind tunnel testing starts.

Overview

The APP team offers a variety of scientific consulting and support services for users to optimize code performance and increase effective utilization of HEC resources and technologies. APP works with users to support projects across all of NASA's key mission areas, including design of future space launch systems, whole-Earth system modeling, aircraft engine performance, and astrophysical simulations to understand the structure of the universe.

Scientific Consulting and Problem Resolution

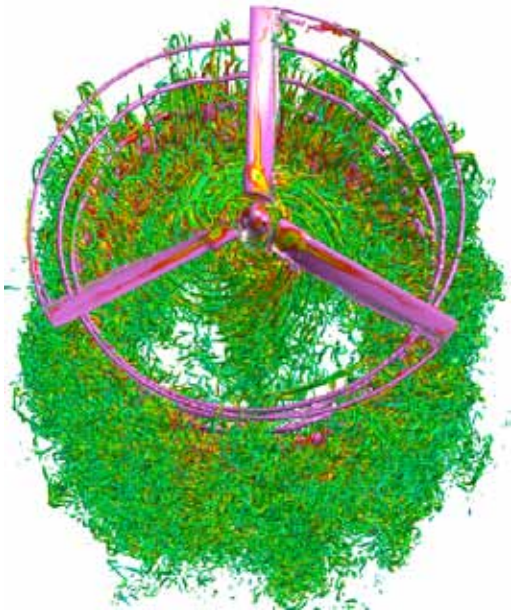
One of the APP team's most important roles is to assist users in all aspects of running their applications on NAS facility supercomputers. This includes trouble-shooting issues with simulation runs, resolving problems with compilers, libraries, scripts, and I/O, as well as general help porting codes from one system to another.



In response to a request from Goddard Space Flight Center's Global Modeling and Simulation Office, the NAS Application Performance and Productivity (APP) team improved the performance of the Satellite Data Simulation Unit (SDSU) code, used to analyze satellite observation data and provide a more complete view of global cloud, precipitation, and aerosols processes. APP experts analyzed the code and improved the parallel efficiency of poorly performing code regions—achieving an 8x speedup on the Pleiades supercomputer. This image shows the important feature of interest in the center of the domain, where tropical cyclone Erin (2007) was observed. (NASA/Goddard)

Application Performance Optimization

APP experts provide code optimization services ranging from small, but high-impact adjustments to comprehensive application reengineering and scaling. In many cases, once the code is optimized, a problem can be solved much faster than before, resulting in reduced turnaround time while requiring fewer resources. This improved performance allows scientists to focus on solving larger or higher fidelity problems.



The APP team worked with OVERFLOW code users to debug and enhance the performance of their simulations, including I/O parallelization to reduce total runtime by 12-15%. This effort allowed a user to run 8x more steps in a single run to facilitate the efficient completion of the simulation. This image shows contours of vorticity for a tiltrotor aeroacoustics model, using 728 million grid points on 192 Pleiades nodes. (Neal Chaderjian, Tim Sandstrom/NASA Ames)

NAS takes a collaborative approach to code optimization—establishing working partnerships between the computational scientists who make codes run well on a given architecture, and the domain experts who know their codes inside and out. This ensures the necessary mix of expertise to address some of the more challenging computational problems.

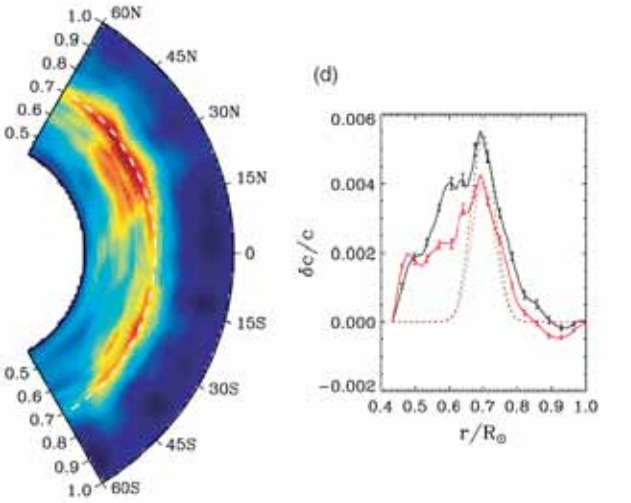
Advanced Technologies

The APP team evaluates, installs, and customizes software tools for NASA application debugging, performance profiling, monitoring, and parallelization. These experts also train users in the effective use of HEC systems and tools. In addition, team members conduct extensive evaluations of advanced hardware and software technologies to identify and leverage those best suited for NASA's evolving HEC challenges. Utilizing synthetic benchmarks and full NASA-related applications, they characterize the performance of current and future architectures, assist users with application modifications to take advantage of evolving hardware configurations, and provide expert advice in selecting and procuring systems to meet NASA's HEC requirements.

In 2011, the APP team redefined the standard billing unit used to allocate computer time and measure computer usage on NASA's HEC systems. They chose six benchmarks representing user applications from all NASA mission areas, including aeronautics research, space operations and exploration, Earth science, and space science. The code execution times were then used to establish charging rates for each supercomputer.

Background

NASA has a core set of computer codes that have been developed over the last 20–30 years. While many of these legacy codes were not originally designed for highly parallel environments, they are still vital to the operation and completion of NASA missions. Over the last decade, NAS has worked to port key NASA codes from vector-based machines to cache-based machines, then to single-system image systems, and now, to distributed memory clusters. These transitions are an integral part of keeping up with the growing supercomputing demands of NASA's missions. As part of this effort, the APP team is working continuously to find new methods to improve the speed and efficiency of NASA codes on current and emerging HEC architectures.



The APP team improved the performance of a solar acoustic computational code, A_SH_B_WAVES, developed at Stanford University. Their simulations play an important role in deriving solar interior properties from observations. By reducing the runtime of this code, the user can attain longer simulation times that provide statistics needed for measuring flows deep in the interior of the sun. The transformed code gains a factor of 4 speedup in the parallel region when run on Pleiades. Overall, code performance (including I/O) sped up by 2.7x. The image shows 2-D inversion results for sound-speed perturbation; and latitudinally averaged results, where solid lines show inversions and dotted lines show the averaged perturbation model. (Konstanin Parchevsky, Stanford University)

For more information on our application optimization services, please visit: www.nas.nasa.gov/hecc/services/application_optimization.html

Point of Contact:
Piyush Mehrotra
(650) 604-5126
piyush.mehrotra@nasa.gov